Issues in dense granular flow

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Size-scaling is a key issue that is common to dense granular flows in both transport and process applications. In order to tease apart this problem, it is important to address the following:

1. What sets the stress and flow fields for the relevant flow regimes? How are stress changes or changes in other quantities transmitted throughout the sample?
2. How are these related to boundary conditions, particle properties, and control parameters?
3. How should one characterize a granular mixture, particularly one where the particles have a continuous range of sizes, shapes and/or surface properties? Given that real granular materials may require a very large number of parameters for a complete physical description, what are the most useful truncations of such a parameter space that give reasonably accurate characterization?
4. What is the range of states that is compatible with a given set of (boundary) control parameters? The answer to these will address the repeatability issue.
5. What is the character of fluctuations that occur in stresses/forces and flow fields? What mathematical approach can be used to incorporate these fluctuations into a suitable theory (e.g. Langevin approach for random uncorrelated fluctuations, extended granular temperature).
6. Is there a connection between the possible states consistent with a set of control/boundary conditions, and the range of fluctuations seen? That is, is the nature of repeatability tied to fluctuations?
7. What is the response of a system to a change at the boundaries?
8. In a dynamical process, what is the relation between energy input and flow?
9. What parameters control the transition(s) between different granular states, e.g. quasi-static vs. intermediate? What is the nature of these transitions?
10. What experimental models would be most useful in a) addressing basic physical questions, and b) providing key insights for practical applications?
11. What diagnostics can be used to infer information of flow fields and stresses both internally and the boundaries?

Specific case studies should address some set of the above questions. They should be industrially relevant, and accessible to experiment and simulation. Ideal studies would include both these last two components. Studies should point in the direction of developing new modeling approaches. They should also consider the effects of vary size scales. This last point is of importance for several reasons. First, scale variations can provide important insights into the nature of the physics involved. And scale-up remains one of the most challenging problems for industrial applications.